

Relationship of sire expected progeny differences to milk yield in Brangus cows^{1,2}

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ABSTRACT: Milk yield from 160 Brangus cows sired by 65 Brangus bulls was measured over a 3-yr period with a single-cow milking machine to estimate the relationship of actual milk yield of daughters and their calves' BW with cow sire EPD for milk during the pre-weaning period. Milk yield was measured six times per year at an average 49, 78, 109, 138, 168, and 198 d postpartum. The regression of daughters' milk yield on sire milk EPD was quadratic ($P < 0.01$), and the initial linear portion of the curve differed among months ($P < 0.05$) at an average cow BW. Similarly, the regression of 6-mo average 24-h milk yield on sire milk EPD was curvilinear ($P < 0.05$). When cow BW was fitted as a covariate in the regression of 6-mo average 24-h milk yield on sire milk EPD, there was an interaction of cow

BW with linear sire milk EPD and quadratic sire milk EPD ($P < 0.10$). The associated response surface suggested that the regression was primarily linear in cows weighing ≤ 520 kg and curvilinear in cows weighing > 520 kg. A trend existed for the regression of calf 205-d weight on grandsire milk EPD to be curvilinear ($P < 0.21$); however, the regression of calf 205-d weight on milk yield of their dam was linear ($P < 0.01$). Results from these data suggest that genetic potential for milk yield, and possibly the associated effects on calf BW transmitted through the grandsire, may have a practical maximum because of nutritional limitations that prevent the expression of genetic potential beyond that level, particularly in heavier cows, which suggests the need to match sire milk EPD and cow BW with production environment.

Key Words: Beef Cattle, Brangus, Milk Expected Progeny Difference, Milk Yield, Preweaning

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Introduction

Milk production in beef cows has an important influence on the weaning weight of calves (Brown and Brown, Jr., 2002) and the efficiency and profitability of cow-calf enterprises (Brown and Dinkel, 1982; Miller et al., 1999). Most beef cattle breed associations publish EPD for various traits, including milk (maternal weaning weight), to allow for comparisons among individual animals for predicted genetic merit. Estimates of milk

EPD for sires allow for estimates of differences in weaning weights of their daughters' progeny attributable to maternal effects in their daughters. Although there is a consensus that increases in milk EPD are associated with increases in milk production and calf weaning weights (Mallinckrodt et al., 1993; Marshall et al., 1993; Miller and Wilton, 1999; Minick et al., 2001), the relationships reported among milk EPD, milk yield, and weaning weight vary with production environment and breed. Minick et al. (2001) stated that higher-milking cows would be expected to require higher levels of feed energy to support milk production, which implies that there may be a practical maximum for milk EPD for given nutritional environments. Consequently, the objectives of this research were to evaluate relationships of Brangus sire milk EPD to their purebred daughters' milk yield and to the weights of their daughters' calves and to determine whether such relationships are curvilinear.

Materials and Methods

All experimental procedures were reviewed and accepted by the Agricultural Research Service Animal

¹Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the USDA and does not imply approval to the exclusion of other products that may be suitable.

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Table 1. Forage quality estimates associated with six monthly milk production measures

Month	April	May	June	July	August	September
CP, % DM	11.1	10.4	5.9	5.9	5.2	4.9
IVDMD, % DM	63.3	64.9	50.3	49.0	50.6	50.5

Care and Use Committee and were in accordance with the Guide to Care and Use of Agricultural Animals in Agricultural Research and Teaching (FASS, 1999).

Registered Brangus females ($n = 246$), representing a wide sampling of the breed, were acquired between 1998 and 2000. Cows were managed on native rangeland, Old World Bluestem, and common bermudagrass during the summer and wintered on dormant warm-season forage with supplementation of hay (prairie hay, bermudagrass, Old World Bluestem) and protein cubes (40% CP, 76% TDN on a DM basis) consistent with forage DM availability and quality. In the spring, cows calved on wheat pasture until spring 2002, when cows were calved on wheat pasture or native rangeland infested with cool-season annuals such as downy brome. Estimates of forage CP and IVDMD for the pastures used in the milk production study, averaged over the 3 yr, are given in Table 1.

Calves were weighed within 24 h of birth, bull calves were banded (Elastrator, Elastrator Ltd., Bibra Lake, Australia), and calves were not creep-fed during the preweaning period. Cows representing 65 Brangus sires were sampled in 2000 ($n = 50$), 2001 ($n = 50$), and 2002 ($n = 60$) for estimates of milk yield. The number of daughters per sire averaged 2.1 and ranged from 1 to 9. Distribution of cows' ages in the study included 41 2-yr-olds, 56 3-yr-olds, 27 4-yr-olds, and 36 mature (≥ 5 yr old) cows. Repetition of cows across years was minimal. Milk yield was measured each year using a single-cow portable machine at an average of 49, 78, 109, 138, 168, and 198 d postpartum. Milk yield measurements started in late April and ended in late September.

Cows and calves were separated at approximately 1900 the evening before milking and held for approximately 14 h overnight with water provided. There was no milk-out before separation. Ten minutes before milking, cows were given 1.5 mL of acepromazine maleate (10 mg/mL, i.m.). In addition, 1.0 mL of oxytocin (20 USP units/mL) was administered i.m. immediately before milking to induce milk let-down. After a cow was milked out, milk was weighed on a digital platform scale. Milk yield was adjusted to a 24-h basis (24-h milk yield) as $(\text{milk weight}/14) \times 24$ (Brown et al., 1996).

Repeated-measures analyses for milk yield were done using least squares mixed models procedures. The initial linear models included fixed effects of year, age of cow, breed of calf sire (Brangus, Hereford, Charolais, Gelbvieh, Romosinuano, Bonsmara), sex of calf, month of lactation, estimable two- and three-factor interactions among the main effects, days postcalving (linear), sire EPD (linear), sire EPD (linear) \times month of lactation,

sire EPD (quadratic), sire EPD (quadratic) \times month of lactation, and a random residual. Sire of cow was not included in the models to prevent removing sire EPD effects. Models were reduced to exclude unimportant ($P > 0.25$) fixed interactions. Analyses of monthly 24-h milk yield and average (average of six monthly estimates) 24-h milk yield were performed with linear models including year, age of cow, days postcalving (linear), sire milk EPD (linear), sire milk EPD (quadratic), and a random residual. Measurement time of day of was evaluated in the milk yield analyses to determine whether the time of day influenced milk yield. In August and September, time of day of measurement influenced ($P < 0.10$ and 0.05 , respectively) milk yield and time of day was included in the models for these months. Analyses for average 24-h milk yield (average of six monthly measurements) also were performed with a linear model that included year, age of cow, days postcalving (linear), cow weight (linear), sire milk EPD (linear), sire milk EPD (quadratic), cow weight \times sire milk EPD (linear), cow weight \times sire milk EPD (quadratic), and a random residual. Maxima for the quadratic equations were calculated as the solution to the first derivative of the equation set to zero. The maxima were calculated to estimate the point in the quadratic curve where increases in sire milk EPD were not associated with increases in daughter milk yield.

Analyses by month of lactation for monthly calf weights were done with linear models that included year, calf sire breed, age of cow, sex of calf, age of cow \times calf sire breed, age of cow \times calf sex, calf sire breed \times calf sex, age of cow \times calf sire breed \times calf sex, two- and three-factor interactions ($P < 0.25$) of year with other fixed effects, days postcalving (linear), grandsire milk EPD (linear), grandsire milk EPD (quadratic), and a random residual. Analyses of calf 205-d weight were done with 1) a linear model that included year, cow age, calf sire breed, calf sex, cow age \times calf sire breed, cow age \times calf sex, calf sire breed \times calf sex, cow age \times calf sire breed \times calf sex, two- and three-factor interactions of year with other fixed effects, grandsire milk EPD (linear), grandsire milk EPD (quadratic), and a random residual; and 2) a linear model that included year, cow age, calf sire breed, calf sex, cow age \times calf sire breed, cow age \times calf sex, calf sire breed \times calf sex, cow age \times calf sire breed \times calf sex, two- and three-factor interactions of year with other fixed effects, average cow 24-h milk yield (linear), and a random residual.

All regression models were subjected to examination of standardized residuals for detection of possible influential outliers. The two observations with the largest negative and the two observations with the largest posi-

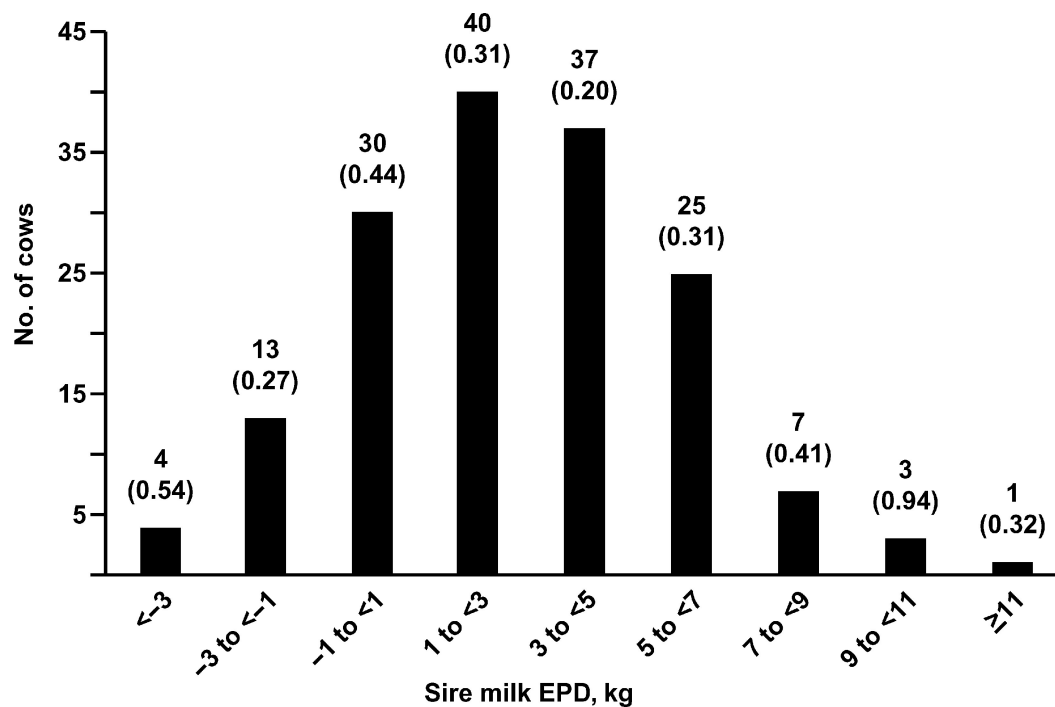


Figure 1. Distribution of sire milk EPD for daughters in the experiment. Average accuracies for each class are given in parentheses.

tive standardized residuals were deleted from the analyses for a particular model. In addition, any observation with a standardized residual ≥ 2.5 also was deleted. After deletion of outliers, data were reanalyzed.

The distribution of sire EPD for the experiment is given in Figure 1. There were 19 cows with sire EPD ≥ 6.7 kg and 30 cows with sire EPD ≥ 6.45 kg (data not shown). The average active sire EPD for milk for the Brangus breed was 3.95 kg in fall 2003, and the average accuracy of milk EPD for all registered Brangus was 0.15.

Results and Discussion

24-h Milk Yield on Sire EPD

Initial repeated-measures analyses for 24-h milk yield indicated that the regression of 24-h milk yield on sire milk EPD was curvilinear ($P < 0.01$), with the linear component differing by month of lactation (sire milk EPD_{Linear} \times month; $P < 0.05$; data not shown). Coefficients for equations for the regression of monthly 24-h milk yield for each of the 6 mo, and 24-h milk yield averaged over the 6 mo (average 24-h milk yield) on sire milk EPD are given in Table 2, and plots of these equations are given in Figures 2 and 3. The initial linear portion of the curve was steeper for April compared with the other months and the local maximum (6.26 kg) was greater than in May, July, August, or September. Multiple R^2 values for the six equations ranged from 0.03 to 0.09. The regression of average milk weight on sire milk EPD was curvilinear ($P < 0.05$) and the R^2 was

0.08. Marston et al. (1992) reported linear regression coefficients for 205-d milk yield on dam milk EPD of 42.1 ($R^2 = 0.10$) and 69.3 kg/kg ($R^2 = 0.19$) for Angus and Simmental, respectively. Marshall and Long (1993) reported the regression of total 214-d milk yield on sire milk EPD as 13.4 kg/kg ($R^2 = 0.02$), and Minick et al. (2001) reported the linear regression of total milk yield on sire milk EPD as 9.63 kg/kg. Diaz et al. (1992) reported a linear regression coefficient of 0.038 for 12-h milk yield on sire milk EPD from Hereford sires, which could be extrapolated with assumptions to 15.58 kg/kg for 214-d total milk yield on sire milk EPD. Baker and Boyd (2003) reported that Angus cows from sires averaging 12 kg of milk EPD had 0.7 kg higher 12-h milk yields than did cows from sires averaging -6 kg milk EPD. Results from the literature suggest that sire milk EPD is related to the actual milk production of the sires' daughters, but with low R^2 .

Results from the analyses of the effect of cow BW on the regression of average 24-h milk yield on sire milk EPD are given in Figures 4 and 5. The response surface (Figure 4) suggests that the relationship of average 24-h milk yield to sire milk EPD was reasonably linear at lower cow BW (< 520 kg), whereas at 520 kg or greater, the relationship becomes curvilinear. Moreover, it seems that the sire milk EPD at which maximum average 24-h milk yield is predicted becomes smaller as cow BW increases (Figure 5). Holloway and Butts (1984) reported that milk yields were similar in large- and small-framed cows on tall fescue, but on a higher plane of nutrition (tall fescue-legume pastures), the large-framed cows had higher milk yield than the

Table 2. Regression coefficients for 24-h milk yield on sire milk expected progeny difference, kg/kg

Month	Intercept	Linear	Quadratic	R ²	Maxima ^a
April	7.4966	0.3334 ± 0.0957**	-0.0266 ± 0.0142†	0.09	6.26
May	7.2348	0.2429 ± 0.0732**	-0.0258 ± 0.0107*	0.07	4.70
June	7.3562	0.2136 ± 0.0720**	-0.0146 ± 0.0090	0.07	7.32
July	6.8166	0.1381 ± 0.0640*	-0.0149 ± 0.0056‡	0.03	4.64
August	6.0290	0.1302 ± 0.0589*	-0.0117 ± 0.0084	0.04	5.55
September	5.2254	0.1947 ± 0.0621**	-0.0223 ± 0.0094*	0.07	4.37
Avg. milk weight	6.7519	0.1996 ± 0.0591**	-0.0173 ± 0.0085*	0.08	5.78

‡*P* < 0.11.†*P* ≤ 0.10.**P* < 0.05.***P* < 0.01.^aKilograms of sire milk EPD.

small framed cows. This finding suggests that under marginal nutrition (tall fescue), the larger-framed cows did not express the potential for milk that was expressed when nutrition was higher (tall fescue-legume).

These data indicate that the relationship of milk yield to sire milk EPD depends on cow BW (cow BW_{Linear} × sire milk EPD_{Quadratic}; *P* < 0.10; data not shown). For heavier cows, there is an indication that increases in sire milk EPD at lower levels of sire milk EPD are more effective in improving the milk yield of daughters compared with increases at higher sire milk EPD. Moreover, there seems to be a practical maximum effective sire milk EPD for heavier cows, above which, increases in daughter milk yield do not occur, with the maximum effective sire EPD becoming smaller as cow BW increases. Nutrient requirements of average-milk-ability (5 kg/d) lactating cows range from 9.1 to 10.6% CP and from 55.3 to 59.4% TDN in the DM (NRC, 1984). In lactating cows of superior milking ability (10 kg/d), these requirements are 11.3 to 16.4% CP and 63.0 to

82.9% TDN in the DM (NRC, 1984). If it is assumed that selection of higher-quality forage during grazing could result in a 3% increase in both CP and TDN, protein and energy provided by forage (Table 1) would not meet nutrient requirements of either average- or high-milking-ability cows in June, July, August, or September. Johnson et al. (2003) reported an increased intake of 0.33 kg of DM of low-quality (52% TDN) bermudagrass hay per kilogram increase in milk yield in Brangus, which is approximately equivalent to 1 Mcal of NE_m/kg of forage. Thus, with each 1 kg increase in milk yield, cows consumed approximately 0.35 Mcal more NE_m. Depending on milk composition, each kilogram of additional milk yield requires approximately 0.75 Mcal of NE_m. Particularly considering the IVDMD values during the last four months (Table 1), it seems that the cows in this study may not have been able to meet the additional energy requirements for increased milk production without drawing from energy reserves.

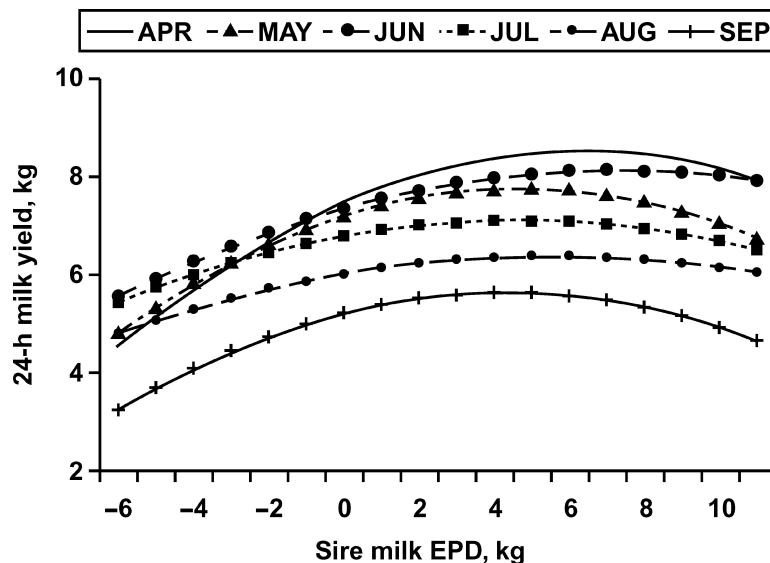


Figure 2. Regression of daughter 24-h milk yield on sire milk EPD for each of six monthly measures. Apr = April; Jun = June; Jul = July; Aug = August; Sep = September.

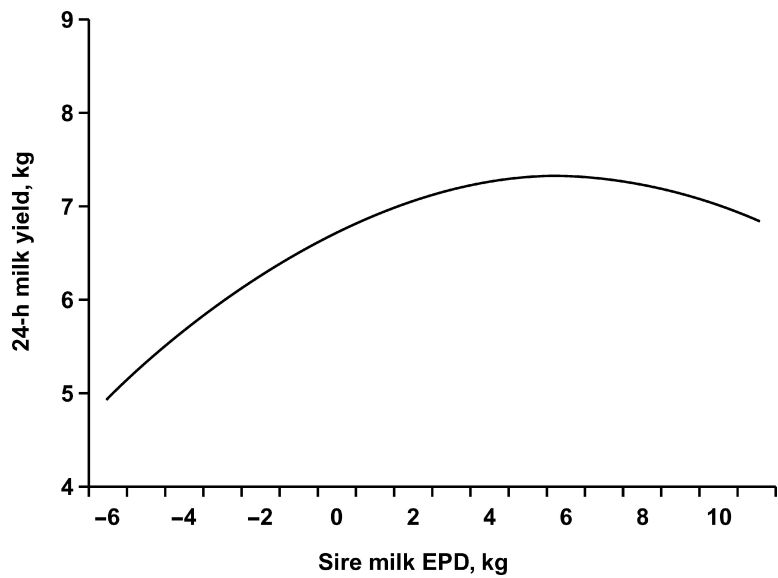


Figure 3. Regression of daughter average 24-h milk yield on sire milk EPD.

To evaluate the effect of changes in nutrient availability (April vs. July grazing) in these data, a subset of the data ($n = 52$) was evaluated for cows that were average (mean = 6.8 kg/d) and high in milk yield (mean = 13.9 kg/d) in April, when nutrition from grazing was adequate (Table 1). Data were adjusted for year,

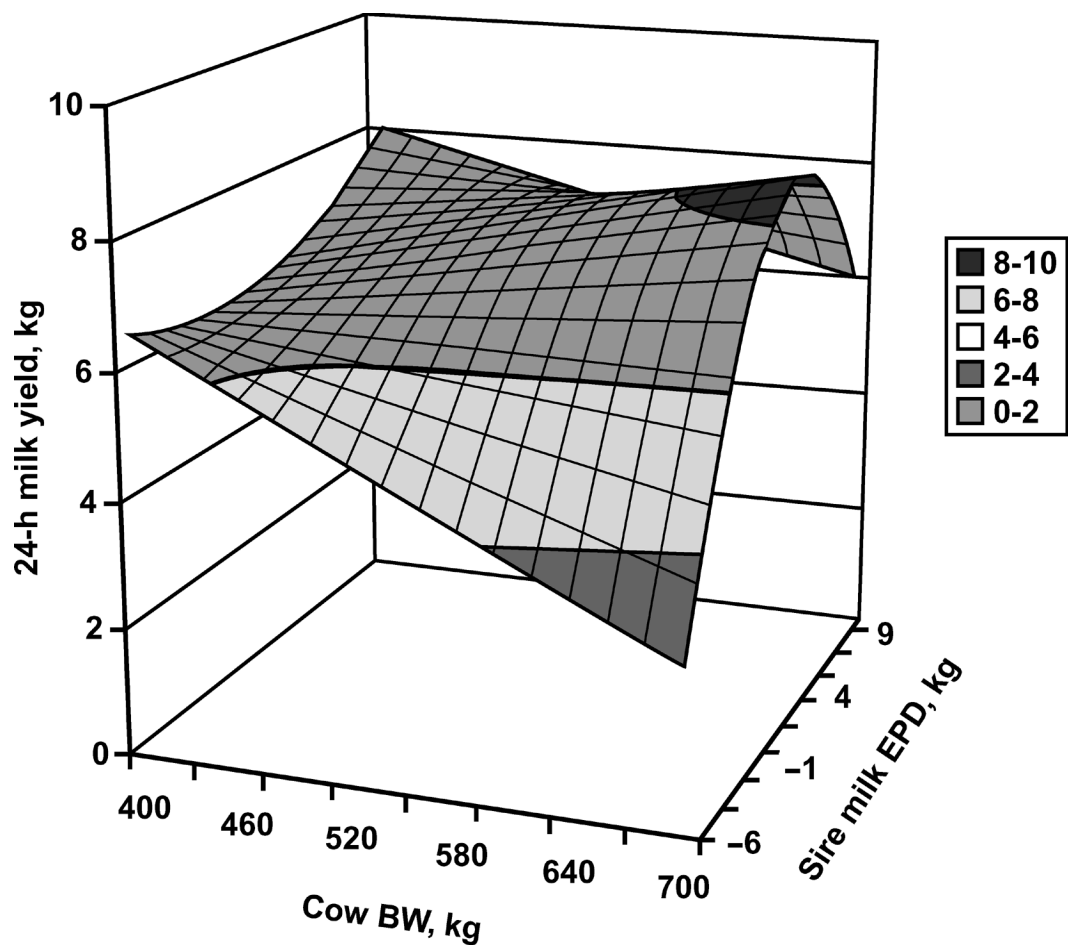


Figure 4. Regression of daughter average 24-h milk yield on sire milk EPD at various levels of daughter BW.

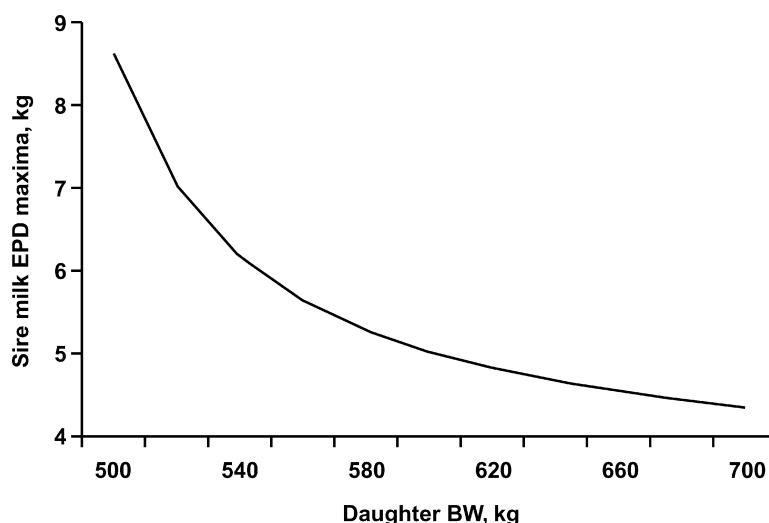


Figure 5. Plot of maximum sire milk EPD vs. daughter BW from the quadratic regression of daughter average 24-h milk yield on sire milk EPD and daughter BW.

age of dam, and days of lactation; cow weight was not an important factor in change in milk yield. Change in milk yield from April to July, when nutrition was lower (Table 1), was greater ($P < 0.01$) in high- (-4.3 kg; $P < 0.01$) vs. average-milking-ability cows (0.1 kg; $P > 0.80$). These results suggest that the decrease in nutritive value of forage had greater effects on higher-milking cows than the cows with average milk yield (data not shown).

We hypothesize that under the nutritional conditions of this research, cows with a BW in excess of 520 kg did not have the nutrition to fully support the expression of their genetic potential for milk yield. Further, as cow BW increased from 520 kg, there seemed to be greater constraints on the expression of genetic potential for milk production. This suggests that the combination of cow BW and sire milk EPD should be matched to the nutrition available to the cow herd, but it does not suggest that production of high-milk-EPD sires is unwarranted. Higher EPD sires will be useful in other situations, such as better nutritional environments and

positive assortative matings to correct deficiencies in milk EPD.

Calf BW on Maternal Grandsire EPD

Initial analyses of regression of monthly calf BW on sire of dam milk EPD suggested a trend ($P < 0.10$) for the linear coefficient to vary with month of measurement (data not shown). Subsequently, analyses of regression of calf BW on grandsire milk EPD were done for each month of measurement fitting a quadratic model for purposes of consistency with the regression of dam milk yield on sire EPD. Coefficients for regression equations for monthly calf BW and 205-d BW on sire of dam milk EPD are given in Table 3, and the plot of the equation for 205-d BW is given in Figure 6. The monthly analyses indicated that the regression of calf BW on grandsire EPD was quadratic ($P < 0.10$) in four of the 6 mo. The local maxima ranged from 3.75 kg in September to 5.29 kg in April with no apparent pattern. Multiple R^2 for the six equations ranged from 0.03 to 0.07.

Table 3. Regression coefficients for calf BW on milk expected progeny difference of grandsire, kg/kg

Month	Intercept	Linear	Quadratic	R^2	Maxima ^a
April	82.41	$0.74 \pm 0.40^\dagger$	-0.07 ± 0.06	0.03	5.29
May	109.96	$1.34 \pm 0.52^*$	$-0.15 \pm 0.07^*$	0.06	4.47
June	135.67	$1.41 \pm 0.63^*$	$-0.16 \pm 0.09^\dagger$	0.05	4.41
July	166.20	$1.77 \pm 0.69^{**}$	$-0.21 \pm 0.10^*$	0.06	4.21
August	192.74	$1.56 \pm 0.83^\dagger$	$-0.17 \pm 0.12^\ddagger$	0.03	4.59
September	218.19	$2.40 \pm 0.84^{**}$	$-0.32 \pm 0.12^{**}$	0.07	3.75
205-d weight	183.66	$2.39 \pm 0.97^{**}$	-0.15 ± 0.11	0.08	7.97

$^\ddagger P < 0.17$.

$^\dagger P \leq 0.10$.

$^* P < 0.05$.

$^{**} P < 0.01$.

^aKilograms of sire milk EPD.

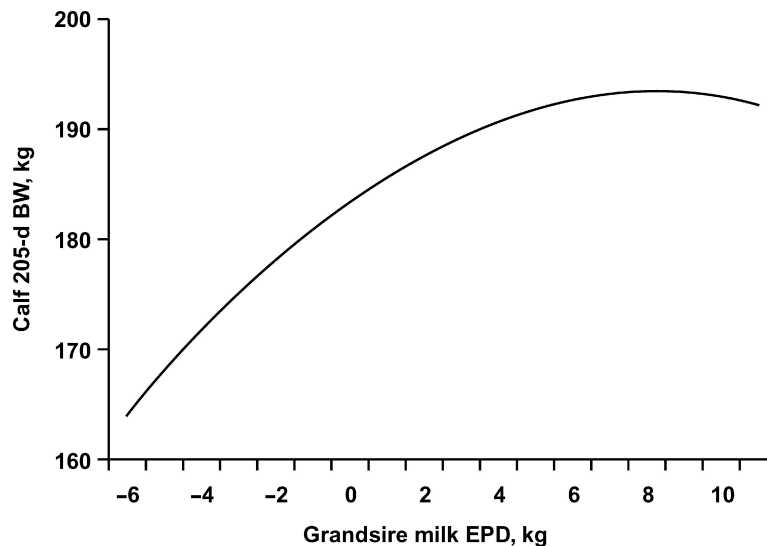


Figure 6. Regression of calf 205-d weight on grandsire milk EPD.

The trend of the regression of calf 205-d BW on grand-sire milk EPD was quadratic ($P < 0.21$) and the R^2 for the quadratic equation was 0.08 (Table 3). Marston et al. (1992) reported linear regressions of 205-d BW on dam milk EPD of 4.85 ($r = 0.38$) and 3.74 kg/kg ($r = 0.39$) for Angus and Simmental, respectively. Mallinckrodt et al. (1993) reported linear coefficients of 2.86 and 1.03 for the regression of 205-d calf BW on sire of dam milk EPD for Hereford and Simmental. Marshall and Long (1993) reported a correlation of 214-d calf BW and sire of dam milk EPD of 0.18, similar to results from the current study. Minick et al. (2001) reported linear regressions of calf 205-d BW on sire of dam milk EPD of 1.04 and 0.83 kg/kg for Angus and Hereford dams.

The data from the current study suggest that the relationship of calf 205-d BW to grandsire milk EPD is curvilinear, but not as strongly so as the regression of milk yield on sire milk EPD. This is reasonable in that 205-d calf weight is affected by genetic and environmental factors other than milk. Nonetheless, there may be

a practical maximum sire milk EPD, above which, there is little improvement in calf 205-d BW, although this does not seem to depend on cow BW (data not shown).

Regression of 205-d BW on Average 24-h Milk Yield

Initial quadratic models of the regression of 205-d BW on average 24-h milk yield of the dam indicated that the quadratic component was unimportant ($P > 0.25$). The linear regression of 205-d BW on average 24-h milk yield indicated that a 1-kg increase in average 24-h milk yield resulted in a 17.2-kg increase in 205-d BW ($R^2 = 0.48$; Figure 7). Expressed as the regression of 205-d BW on 205-d total milk yield (average 24-h milk yield \times 205 d), the regression coefficient is 0.0839 kg/kg. Marston et al. (1992) reported linear regressions of 205-d BW on total milk yield of 0.014 ($r = 0.30$) and 0.032 ($r = 0.47$) for Angus and Simmental cows and their calves. Mallinckrodt et al. (1993) reported linear coefficients of 7.05 and 4.67 kg/kg for the regression of

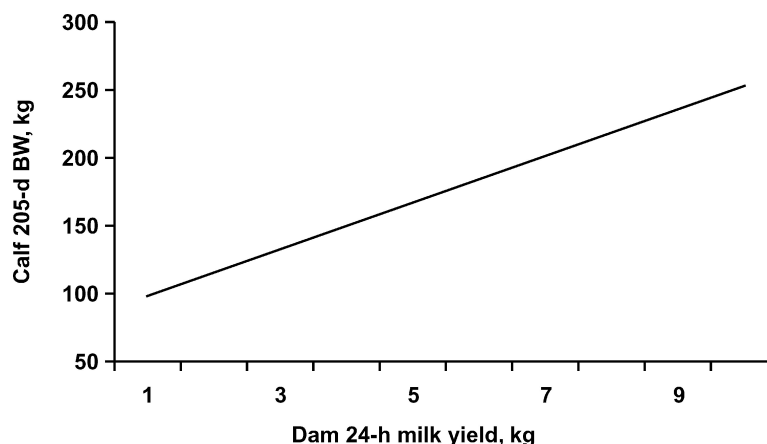


Figure 7. Regression of calf 205-d weight on dam average 24-h milk yield.

205-day BW on average 24-h milk yield. Marshall and Long (1993) reported a simple linear correlation of 0.52 between total milk yield and 214-d calf BW. Baker and Boyd (2003) reported a linear correlation of 0.87 between total milk yield and weaning weight in Angus cows. Results from the current research are consistent with the literature, clearly documenting that dam milk production is an important component of calf weaning weights.

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